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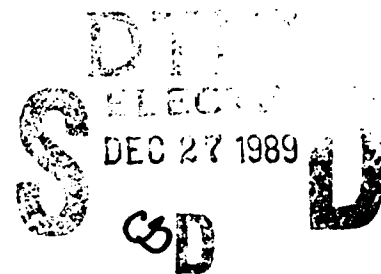
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**DAMAGE ASSESSMENT IN COMPOSITES
BY ACOUSTO-ULTRASONIC TECHNIQUE**

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DAMAGE ASSESSMENT IN COMPOSITES BY ACOUSTO-ULTRASONIC TECHNIQUE

OBJECTIVES

The main objective of the research was to develop and refine the acousto-ultrasonic technique to assess damage in composite materials. Specifically, this research was directed toward three goals: (1) to improve the acousto-ultrasonic technique by focusing on the understanding of the relationship between material properties and wave propagation, (2) to establish operational methods for research and industrial applications, and (3) to improve material characterization and damage assessment using the refined technique.

SUMMARY OF RESULTS

Both analytical and experimental approaches were employed to optimize the acousto-ultrasonic technique. The following topics were investigated in the study:

- Calibration of acoustic emission system and preamplifier
- Characteristics of the output wave from transducer
- Acousto-ultrasonic wave propagation in composite laminates
- Evolution of acousto-ultrasonic wave envelope in composite laminates
- Propagation of different waveforms
- Assessment of impact damage
- Assessment of ply cracks
- Assessment of cut fibers

The acousto-ultrasonic waves used in the present study were generated by a transducer which was attached on the surface of the composite laminate. Although the generation and propagation of these waves was quite complex, the most dominant of the detected waves could be approximated by a plane Lamb wave because the measured speeds were quite close to the calculated ones.

The acousto-ultrasonic waves were found to be sensitive to all types of damages investigated. Since the involved measurement is rather simple, the technique would be applicable to structures having complex shapes. One drawback is that although higher frequency waves are more sensitive to damages, these waves are more complex to analyze especially in thick laminates. Further results are summarized as follows.

Lamb wave speeds were calculated in the low frequency region for a unidirectional graphite/epoxy laminate. For wave propagation in off-axis directions transverse displacement was assumed zero. Experimental verification was carried out by measuring the wave speeds on the upper and lower surfaces of the specimen. The changes of the wave velocity and attenuation with frequency were monitored. Fourier spectra of the received signals were obtained using a wave analyzer to study dispersion. It has been found that the dominant AU waves produced experimentally were Lamb waves. The wave velocity changed with the fiber direction in the predicted manner.

INDEX OF TECHNICAL REPORTS

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2. S.M. Moon, H.T. Hahn, K.L. Jerina, "Evolution of the Wave Envelope in Composite Laminates in Acousto-Ultrasonic Technique," Report No. 8815, The Pennsylvania State University, Aug. 1988.
3. S.M. Moon, H.T. Hahn, K.L. Jerina, "Detection of Impact Damage in Composite Laminates by Acousto-Ultrasonic Technique," Report No. 8816, The Pennsylvania State University, June. 1988.

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1. S.M. Moon, K.L. Jerina, H.T. Hahn, "Acousto-Ultrasonic Wave Propagation in Composite Laminates," Acousto-Ultrasonics Theory and Application, Ed. John C. Duke, Jr., Plenum Press, pp. 111-125.
2. S.M. Moon, H.T. Hahn, K.L. Jerina, "Evolution of the Wave Envelope in Composite Laminates in Acousto-Ultrasonic Technique," Conference on Nondestructive Testing and Evaluation for Manufacturing and Construction, University of Illinois, August 10-12, 1988. (Co-author), To be published.
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4. S.M. Moon, H.T. Hahn, K.L. Jerina, "Detection of Impact Damage in Composite Laminates by Acousto-Ultrasonic Technique," 4th Japan-U.S. Conference on Composite Materials, Washington, DC, June 7-29, 1988. (Co-author) pp. 92-105.
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